UNITED STATES GOVERNMENT

MEMORANDUM

DATE: September 7, 1994

REPLY TO ATTN OF: Rod Small: Acting Chief, Frequency Allocation Branch
H. Franklin Wright: Chief, Frequency Liaison Branch

SUBJECT: Ex parte filing

TO: William F. Caton, Acting Secretary

In connection with experimental authorization numbers 2174-EX-PL-91, S-1223-EX-93, and S-1200-EX-93, Omnipoint Corporation filed its August 1993 Semi-Annual Experimental License Report with the Office of Engineering and Technology. This report has an attachment that addresses aspects of Qualcomm, Inc.'s system, for which Qualcomm requested a pioneer's preference (PP-68) in the PCS proceeding, GEN Docket No. 90-314.

Qualcomm's pioneer's preference request was formally opposed and is thus a restricted proceeding. The General Counsel's office has determined that Omnipoint's August 1993 Report violated the Commission's ex parte rules by criticizing Qualcomm's proposed personal communications services technology. Pursuant to the Commission's ex parte rules, we request that the Omnipoint August 1993 Semi-Annual Experimental License Report be placed in a file associated with, but not part of, the record in GEN Docket No. 90-314. See 47 C.F.R. Section 1.1212 (d).

Thank you for your cooperation in this matter. Contact Tom Derenge at 653-2433 if you have any questions.

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

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August 19, 1993

HAND DELIVERY

William F. Caton
Federal Communications Commission
1919 M Street, N.W.
Room 222
Washington, D.C. 20554

Re: Call Sign KK2XCV
File Number 2174-EX-PL-91
File Number S-1223-EX-93
File Number S-1200-EX-93

Dear Mr. Caton:

On behalf of Omnipoint Corporation, we are herewith transmitting an original and four copies of its Semi-Annual Experimental License Progress Report.

Any questions regarding this filing should be directed to the undersigned counsel.

Very truly yours,

Mark J. Tauber

cc: Thomas B. Stanley
David R. Siddal
Stevenson S. Kaminer
Thomas P. Derenge
Robert M. Pepper
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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

In the Matter of	)	GEN Docket No. 90-314
	)	
Omnipoint Corporation	)	Experimental License Report:
	)	Call Sign KK2XCV
Amendment of the Commission's	)	File Number 2174-EX-PL-91
Rules to Establish New Personal	)	And STAs:
Communications Services	)	Call Sign KK2XCV
	)	File Number S-1223-EX-93
	)	Call Sign KK2XCV
	)	File Number S-1200-EX-93

Omnipoint Corporation

Semi-Annual Experimental License Progress Report

August 1993

Omnipoint
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Omnipoint Experimental License Report
August 1993

1 Overview

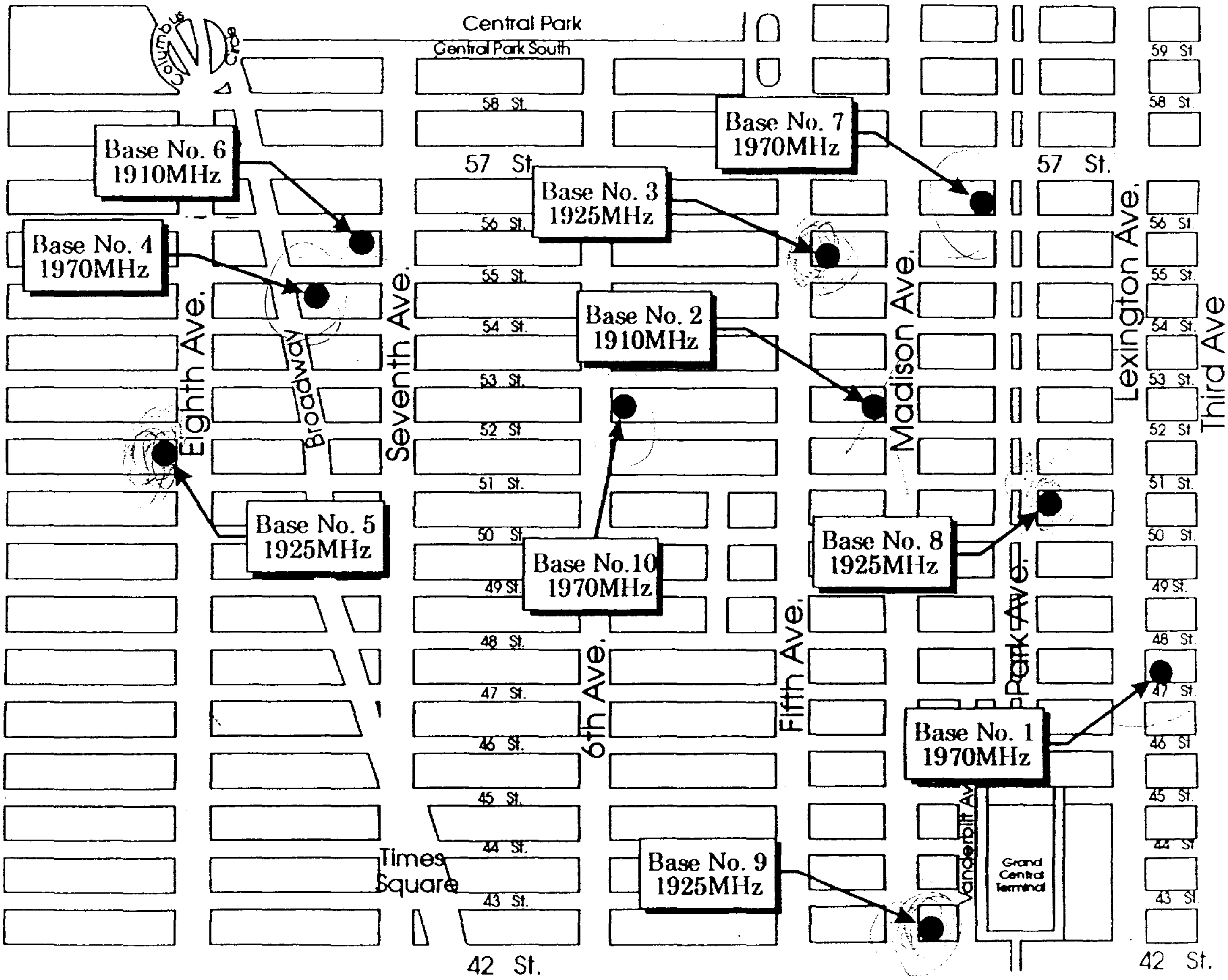
In addition to the numerous tests which Omnipoint has conducted of its 1.9Ghz PCS system with other companies over the past two years, Omnipoint has undertaken solely at its expense one of the largest and most comprehensive set of technical trials of any PCS system. We have conducted both microcell (2000 feet and under) multicell tests as well as macrocell (greater than one mile radii) multicell tests, all with full mobile handoff, and using at most an N=3 reuse pattern. In conjunction with LCC, one of the premier RF consulting and cell site planning firms in the country, Omnipoint has performed extensive testing of its system in highly diverse RF environments. This Progress Report documents the recent large scale tests in New York City and Colorado Springs.

In the New York City area Omnipoint has spent millions of dollars to conduct a trial of its system using up to 12 cell sites to demonstrate the functionality and economics of its network architecture in a true microcellular, N=3 reuse, dense urban environment. Omnipoint spent several months modeling the RF environment of Manhattan, designed and built a micro network, performed extensive field studies of the propagation and multipath characteristics of this unique RF environment, and performed extensive drive and walk tests of its 1.9Ghz PCS network and handsets.

In parallel, to demonstrate the Omnipoint system in less of an "urban canyon" RF environment, Omnipoint constructed 3-4 cell configurations in Colorado Springs, CO ("COS") which includes 3 - 6 miles of coverage along the major interstate highway, plus complete coverage of a single neighborhood quadrant within the total area covered by the configuration of cell sites. This quadrant is slightly larger than a square mile in area and includes a residential neighborhood, several office complexes, multiple small businesses, and strip malls.

Note that Colorado Springs is the 52nd largest city and the 84th largest MSA in the U.S. This means that roughly 90% of the MSAs/RSAs are smaller in population. Thus, real world cell site testing and economic planning of a PCS network in COS is highly meaningful if PCS is ever to offer the promise of near universal service. Several PCS technologies are too expensive in just their initial base station and cell site costs to justify constructing a network to be the fourth, let alone fifth, sixth, etc. operator in a city such as Colorado Springs. Omnipoint is designing its system to lower the infrastructure costs to the point where PCS can be provided to virtually any community.

Omnipoint CORPORATION



Manhattan Test Base Station Locations
Configuration No. 1

Both the New York and COS tests were conducted with at most an N=3 frequency reuse pattern. Frequencies were selected after careful examination of the OFS frequencies in use within the theoretical OFS exclusion zones for each location. For the Colorado Springs tests, we selected two of the 10Mhz channels such that they employed the same frequency division duplexed (FDD) 80Mhz separation as the existing OFS channelization scheme. Although Omnipoint's system is being tested in a time division duplexed (TDD) configuration, Omnipoint will use the proposed FDD PCS spacing of 80Mhz to improve the PCS reuse pattern and mitigate adjacent channel issues. Thus, testing with the 80Mhz FDD channelization was a key element of the Colorado tests.

BACKGROUND TO THE NYC AND COLORADO TECHNICAL TRIALS

Perhaps one of the most important and yet most overlooked aspects of PCS at 1850-1990Mhz will be the problem of acquiring cell sites. This problem is compounded by the fact that there will inherently be many more cells required to offer full functionality 1.9Ghz PCS as compared to 800Mhz PCS. Cells at 1.9Ghz will be smaller than 800Mhz cells for several reasons: 1) Average received signal strength (RSS) levels are 10-15db lower (not just the 6.8db which theory would predict); 2) Fast fading is much more frequent; 3) Deep fades are much more probable; 4) The rate of fading is more than two times faster; 5) Shadowing is much greater (average signal strength can easily drop 25-30db around a corner or behind objects); and 6) Handsets will be limited to lower power levels (i.e., roughly 300mW) which will cause all PCS systems to be uplink limited. (See Figure 3-5 for comparison of 800MHz and 1.9GHz.)

The fact that many more cell sites will be required per operator coupled with the increase in the number of operators will virtually mandate that zoning boards will prohibit the general construction of classical cellular type towers with 100'-200' foot or higher antennae heights. No community is likely to allow its skyline to resemble that of an oil field with hundreds of derricks. This means that cells will have to be mounted on existing structures and be highly inconspicuous. In suburban residential neighborhoods this may mean using existing telephone and cable TV poles and cabling. However, mounting antennas at 25 feet will again dramatically reduce the cell coverage, as shown in Figure 3-6, thereby yet again increasing the number of required cell sites.

The requirement for many more cells dictates that the cost per cell and the cost per cell site installation must be dramatically reduced if new 1.9Ghz PCS networks are to be economically competitive to existing 800Mhz wireless networks and offer consumers reduced prices.

Omnipoint spent much of its infrastructure design and development efforts focused on reducing the cost and size of its base stations and reducing the cost of internetworking them. Further, we have designed the architecture to distribute the processing as much as possible back to the concentration points -- e.g., the Base Station Controllers and the master switching network (which may be a PCS Telephone Switching Office (PTSO), or the standard Public Switched Telephone Network (PSTN)).

Omnipoint has designed six classes of base stations. The smallest is currently 3.5" x 8.5" x 10" and can be mounted virtually anywhere including in the ceilings of most offices (for coupling to outdoor or indoor antennae) or even hanging from standard telephone or CATV lines. A future version one half that size is being developed for even easier mounting. We believe that the availability of this small size a base station is necessary to increase the PCS operators flexibility in choosing cell sites, and particularly critical for "filling in" coverage holes due to variations in terrain and building shadowing. Progress reports regarding Omnipoint's tests with several Cable TV operators have also demonstrated the benefits of such small base stations, especially for mounting from the "strand" itself. Typical cell site equipment for other technologies is measured in each dimension in terms of multiple feet even for so called microcells, and will require floor space or roof space with all the concomitant needs for housing and access.

As will be seen in more detail below, cells in Manhattan do not propagate as concentric circles. Rather, depending upon the exact antennae mounting, standard cells propagate in patterns which primarily resemble lines and crosses. As an example, Figure 1-4 shows the -85dbm mean RSS pattern for one particular site. Even more important, the fast fading characteristic of 1.9Ghz in Manhattan are such that as many as 1% of the fades will drop the RSS below -110db as a close as one block away around a corner or on the opposite side of the building from the cell site (See Figures 1-5 vs. 1-6).

This phenomena lead Omnipoint to design, install, and test the diagonal, cross grid, cell site pattern in Manhattan detailed below.

The Omnipoint handsets used for the Manhattan and Colorado Springs tests have receiver sensitivities of a maximum of -93dbm to -95dbm at a zero Frame Error Rate. In deep fading or high shadowing environments, RSS below -95dbm causes packet muting. Above a Frame Error Rate of 10-2 this muting becomes audible as interruptions to the voice quality (almost universally, but mistakenly, referred to as "pops and clicks").

Based on actual experimental data, the wideband nature of Omnipoint's signal appears to provide 5-8db of resistance to frequency selective fades compared to narrowband signals as shown in Figures 3-1 and 3-2. Fast fading data collected from several environments suggests that 17-18db of fade margin is required to maintain a Frame Error Rate (FER) of less than 2%. (See Figures 1-19 to 1-24.) Thus Omnipoint targets its cell site configurations to provide average RSS of -85dbm within the coverage area of each cell as well as the overlap zones between cells. Except in multipath or shadowing environments which exceed the above fading margins, this target RSS generally provides excellent voice quality. This is particularly evidenced in the Colorado Springs tests.

However, Omnipoint is not satisfied with the performance of the current implementation of the system at these target RSS and fade margins given the high degree of multipath and shadowing actually experienced in many real world environments at 1.9Ghz. Work has been ongoing to increase the receiver sensitivity of the link to up to -104dbm before fade margin. Further, all of the tests to date of Omnipoint's system which have been reported on (including those below) do not use combining diversity. This has been implemented in two lab prototypes and has been shown to significantly improve performance as expected. These will be used in future tests.

2 System Description

Handoff in the Omnipoint system is mobile-centric (i.e., handoff to a new Base Station is directed by the mobile) in contrast to all existing cellular systems which are net-centric (i.e., the network makes the handoff choices and decisions even if using RSSI and FER information gathered by the handset for helping determine the handoff, such as in MAHO systems). This unique feature of Omnipoint's architecture allows handoffs from one base station to another on any of the frequencies throughout the 140Mhz of the 1850-1990Mhz band to be performed in tens of milliseconds even when the link to the original base is lost before signaling information can be completed. The major benefit of this design feature is to allow high speed handoff in very small cells. This technique was the subject of much of the testing in Manhattan and Colorado Springs.

In general, in the test configurations used to date, the Omnipoint handsets will attempt a handoff at mean RSSs of between -85dbm and -90dbm, depending on the FER due to the rate and duration of fading below -95dbm. Based on the qualitative Figure of Merit (FOM) scores shown for the two representative Manhattan cell site coverage plots shown, it can be seen that this generation of handsets can hold the link to areas where the 1% CDF fades average to -105dbm. See Figures 1-8 to 1-11.

Drive tests in both Manhattan and Colorado Springs have demonstrated excellent voice quality over 99% of the routes covered by using the above RSS and fade margin targets for cell site choices. One has to recall that Omnipoint's systems are transmitting several hundred thousand bits per second with only 100mWatts and operating in a fully mobile Rayliegh fading environment without the use of equalizers or combining diversity. However, because the combining diversity receivers were not used for these tests while fades up to 30db and even 40db were occasionally noted (especially in Manhattan in NLOS conditions), so called "pops and clicks" could occur in locations even where mean RSS was recorded at -85dbm. Omnipoint expects the next iteration of testing with the upgraded equipment to show that this will have largely been eliminated.

All tests to date, including those by Omnipoint's customers, of Version 1.X of the system and pocket phones have been performed at peak transmit powers of 40 to 100milliWatts at both the base station and the handset. This is in stark contrast to systems which transmit 5-40Watts of power. Omnipoint's system has frequently been compared to CT2 systems due to Omnipoint's low transmit powers. Yet upbanded 1.9Ghz CT2 systems generally transmit 30mW to 40mW to deliver one voice channel within a 100KHz, transmitting at a 72Kbps simplex data rate. Omnipoint's system has achieved data rates which are over seven times the CT2 data rate (and then TDMA this to support many users) with only 2 -2.5 times the peak transmit power, and performed with high quality over several thousand feet, i.e. distances far in excess that of CT2 systems. Further, Omnipoint's system operates at vehicular speed mobility, can perform frequency agile handoff to any of 28 center frequencies across the entire 140Mhz of the 1.9Ghz band, handles two way calling, messaging, packet data as well as high speed data, and can be used for ~~both~~ symmetric and asymmetric high speed data applications. Finally, Omnipoint's system has been documented to cause significantly less interference to incumbent OFS users than other PCS systems.

3 System Configuration

Omnipoint's system uses a proprietary direct sequence spread spectrum modulation technique to drive the data rate up to very high levels without the need for expensive and power consumptive equalizers. We then use a TDD/TDMA scheme to multiplex users within a cell. Immediately adjacent cells are on separate frequencies (FDMA), which allows for an N=3 pattern to provide at least one cell separation before reusing frequencies. When frequencies are reused, the cells can employ different code sets or different code offsets in addition to different time slots to reduce interference from cochannel interferers.

A number of major benefits are achieved by employing this hybrid architecture. First, there is no near/far problem within a cell since every user is on at a different time. Thus, the need for precision adjustable power controls is eliminated as well as the requirement that every cell be under the control of one centralized network, employing a centralized packet router and requiring separate compare and select functions for every user which is in soft handoff (which has been estimated by others at 50%-70% of all active users). All of that adds significant, linear, expenses to the per user infrastructure costs. Second, Omnipoint's system allows for independently owned and operated base stations, which is critical for use in the unlicensed bands. This allows one handset to be used in both public and private applications. Third, Omnipoint's system allows for one Common Air Interface which can provide both variable rate vocoder rates, variable rate packet data rates, and high speed data channels from 64Kbps to 256Kbps full duplex, and up to 512Kbps in an asymmetric broadcast mode with slow speed ACKs. Fourth, because only one transmitter is on at any instant in time on any given RF channel and because the energy is spread across the OFS receiver's bandwidth, the interference to the incumbent OFS users is dramatically reduced (as documented by numerous experimental reports); and Fifth, because the Base Stations only require one RF card and one correlation chain regardless of the number of users per RF channel (up to the maximum of the RF channel's capacity), the cost per delivered channel is inversely proportional to the number of users. This allows for dramatic cost savings of the PCS infrastructure relative to technologies such as FDMA and CDMA-only which have inherently linear costs per user.

With regards to spectral efficiency comparisons to other PCS systems, Omnipoint has been extremely reluctant to make capacity claims until much more extensive testing has been done in highly loaded conditions. However, we offer the following outline of the basic system parameters and production targets, knowing we will be critiqued by our competitors prematurely.

The Omnipoint system can be configured in multiple ways along several dimensions. Given that all the other Omnipoint system parameters are fixed we can calculate what the maximum-achievable data rate is for any given bandwidth. To date, Omnipoint has only explored bandwidths between 10Mhz and 5Mhz, as we noted in our pioneers preference application, replies, and accompanying experimental reports. For illustrative purposes, and ease of comparing capacity to a narrowband CDMA-only system, we can analyze the lower bound of the bandwidth configurations tested. Omnipoints architecture can straight forwardly achieve a bearer channel rate of 512Kbps, after all overheads, within a 5Mhz simplex bandwidth for operation in TDD mode, using an N=3 frequency reuse pattern.[1]

This results in a delivered data rate efficiency of:

(5000Khz/512Kbps) = 9.766Hz/bit x N=3 = 29.297Hz/bit

By way of comparison, the FDD, N=1, 1.9Ghz Qualcomm system as estimated by APC provides 18.8 users in 2.5Mhz. Since Qualcomm has stated that the system achieves its maximum number of users at a vocoder rate of 3.2Kbps per user, this system delivers (18.8 x 3.2) = 60.16Kbps in 1.25Mhz, which when used in an FDD mode results in a delivered data rate efficiency of:

(2500Khz/(60.16Kbps x 2)) = 20.778Hz/bit

At this point in any capacity comparison, one has to agree on the ground rules.[2] Whereas one PCS system may be optimized for compressed voice and have upper limits on achievable data rates of 9.6Kbps per user, Omnipoint's system is optimized for higher speed voice and data

[1]Overheads include addressing, a 500bps "D" channel per voice channel, error detection, and guard time for TDD and ramp up/ramp down time.

[2]Note that if one makes the comparison based on aggregate transmitted data as opposed to bearer channel data, the Hz/bit of the two systems becomes even closer.

services[3] Consider PCS applications which are more asymmetric in their data flows such as data broadcasting, image transmission, or even Faxes. How does one compare the "efficiency" of delivering digitized video for remote diagnostics when Omnipoint's system can provide this service and the other system can not. Or consider that Omnipoint's system can be used to broadcast a 3.5Mbyte database such as an electronic newspaper in 55 seconds whereas a 9.6Kbps system would take 49 minutes and a system with a 3.2Kbps average rate would take 2 hours and 35 minutes to transmit the file. Or with respect to an even more common application, which PCS system is more efficient: one that uses 400Khz per delivered Fax channel or one that uses 281Khz per delivered Fax channel?

Finally, consider perhaps the most difficult comparison: Omnipoint's system is designed to also operate in the unlicensed bands as well as the licensed bands. But if the capacity of independently owned systems operating in the unlicensed bands is the criteria for capacity comparisons then a CDMA-only system would experience tremendous capacity losses. CDMA-only systems would be unable to operate in an N=1 reuse with nearby independently operated systems on the same frequency. Further, CDMA-only systems would experience capacity reductions across all users in a network due to collisions from even one transmitter from another network. In contrast, Omnipoint's systems would only experience collisions on individual time slots from systems on the same frequencies, which can be resolved through time slot interchange.

There are even more subtle problems with comparing the "capacity" of such disparate PCS systems. With a CDMA-only system, as cell sizes shrink and more cells are operating in proximity, interference rises. One recent study by Rappaport and Milstein, ("Effects of Radio Propagation Path Loss on DS-CDMA Cellular Frequency Reuse Efficiency for the Reverse Channel", IEEE Transactions on Vehicular Technology, August 1992) indicates that CDMA-only systems will experience a six-fold reduction in capacity as cells are reduced from 10 kilometer to 2 kilometer radii.

Omnipoint's system is primarily a TDMA system within a cell, thus Omnipoint does not need to design cell site reuse locations based on worst case C/I ratios since Omnipoint's system can use time slot interchange within a cell to mitigate collisions occurring between individual users operating on cochannel frequencies but in different cells. Coupled with an N=3 reuse pattern, Omnipoint's system capacity in microcells is far less affected by the increase in potential interference sources.

[3] Some parties argue that significant sectorization gains are only possible with CDMA-only systems. Omnipoint does not agree with this but is not yet ready to release data on how much sectorization gain can be achieved with the Omnipoint system. Also, Omnipoint is working on implementing voice activity detection (VAD) as well.

In summary, Omnipoint has avoided capacity claims and capacity comparisons to date because it has focused on developing its vision of a PCS service offering, which provides:

- Wireline quality voice, data, digitized compressed video, and multimedia
- Delivered wirelessly to pocket sized devices
- Allowing handsets to be used with both public or private base stations, in licensed or unlicensed frequencies
- Providing full coverage and full mobility
- At substantially reduced costs

4 Manhattan Tests

4.1 Incumbent OFS Coordination

In order to perform a detailed test in Manhattan as outlined above, multiple Base Station locations were required to support simultaneous transmissions in an N=3 re-use pattern. Omnipoint's current Experimental License for the OFS Band (No. KK2XCV, File No. 2174-EX-PL-91) allows for only 3 Base Stations and 24 Handsets to operate simultaneously anywhere in the continental United States.

Eventual large scale test plans in Manhattan called for up to 100 Base Stations and 200 Handsets, which is well beyond the scope of the original Experimental License. In order to proceed with these large scale tests, Omnipoint requested and received a Special Temporary Authorization (STA) for Manhattan that permits simultaneous use of up to 100 Base Stations and 200 Handsets.

Omnipoint has agreed to coordinate the with all incumbent OFS users in the area surrounding New York possibly affected by Omnipoint's system and to notify the local FCC field office. Prior to over-the-air testing under authority of the STA in Manhattan, an extensive survey of all OFS users within a 50 kilometer radius of Midtown Manhattan was performed by LCC, Inc., of Arlington, Virginia. LCC is a recognized leader in the industry for RF site acquisition and planning, and conducted it's survey through an extensive data base of users and signal propagation simulations and analysis of those sites thought to be potentially affected by the tests.

LCC OFS Interference Analysis Methodology

Analysis - PCS to OFS interference is the most important aspect of the frequency selection process. Avoidance of any possibility of interference to fixed microwave from an Omnipoint PCS technical trial is extremely critical, therefore, very conservative assumptions were employed in the analysis. In order to simplify the analysis, the receive center and adjacent frequencies of the two microwave sites located immediately adjacent to the coverage objective were eliminated from consideration as clearly unusable. The remaining sites were analyzed to predict the co-channel signal level that the microwave receiver would receive from a PCS Base Station within the coverage objective area. Each center frequency was evaluated based on the co-channel received signal strength at each microwave receiver on levels to microwaves on adjacent frequencies.

Assumptions -

1) Per TSB10-E, the maximum allowable PCS signal at the input of any microwave receiver is 10dB below the noise floor of the receiver. For the worst case of a 5MHz microwave, this corresponds to -106dBm, so the maximum allowable PCS signal is -106dBm - 10dB + 3dB (noise figure) = -113dBm. This is a very conservative criterion, since it:

a) Assumes that noise in the receiver is equal to thermal noise in a 5MHz bandwidth, when the actual noise floor is certainly at least a few decibels (only three assumed for this analysis) higher due to the noise figure of the receiver.

b) Protects the microwave receiver in a fully faded condition

c) TSB10-E analysis assumes narrowband interference into the microwave receiver. Omnipoint's wideband direct sequence CDMA signal cause 10 - 20dB less interference into a target microwave receiver than would narrowband systems (See Omnipoint Communications Request for Pioneer's Preference, May 4, 1992). However, narrowband signal analysis was employed in the study, giving even greater margin of safety.

2) Propagation predictions used the Hata/Okumura model and are based on USGS 3-second terrain data. They include the actual antenna gains, line losses, and transmitter output powers of the microwave transceivers. They do not utilize the actual patterns of the microwave antenna, which were not available, but rather use a worst case assumption of beam width and

front-to-back ratio based on Part 94.75 of the FCC Rules. This results in predictions of PCS-to-OFS interference levels which are as high as could possibly be generated by a microwave antenna which is in absolute minimum compliance with the law. Actual antennas generally have a much better performance than this worst case assumption.

3) The initial target coverage area is defined as the area bounded by 59th Street to the north, 42nd Street to the South, 6th Avenue to the West, and 3rd Avenue to the East. While it was assumed that all Handsets and Base Stations are operated only inside this boundary, operation several blocks outside would not cause any further problems than those analyzed inside the coverage area.

4) Substantial blockage caused by the height and density of the buildings in Manhattan should keep the PCS signals well contained. However, as an additional margin of safety, no attenuation due to building clutter is included in the analysis.

OFS Analysis Results

As a result of this analysis, LCC determined that there were only three OFS channels (1910MHz , 1925MHz, and 1970MHz) which were available for testing without having to go to extreme coordination lengths. While these particular tests were not designed to analyze the sharing problem, it is clear that the problem of dodging the OFS beampaths will be a significant one if only 20MHz per PCS operator is authorized. Note that two of the three channles which would not conflict with any OFS beampath were in the portion of the band targeted for Unlicensed PCS only.

In order to further assure that incumbent OFS systems in the area experience no disruption, a series of steps were taken:

1. Omnipoint notified all pertinent OFS operators (co-channel and adjacent channels) and the local FCC field office (See Appendix 1, Omnipoint Manhattan Technical Trial Contact List) prior to commencement of the tests, and continues to notify all parties on a daily basis when tests are being conducted.

2. All affected parties have been supplied with initial locations of the Base Stations, informed of the nature of the tests being conducted, and provided with technical parameters of

the Omnipoint system. Due to the nature of the tests, which involve different placements of Base Stations within midtown Manhattan, daily notification of changing sites is also given.

3. All parties on the contact list have been provided a representative at Omnipoint in the event that interference to the incumbents occurs. This contact has the authority to terminate all testing until it can be determined the source of the interference.

4.2 Manhattan Site Identification and Description

Manhattan Test Configurations

As detailed in the executive summary, Omnipoint believes that envisioned PCS services will be successful only as they become highly cost effective to the end user. In order to meet this goal, minimal network infrastructure costs are a requirement. A dense urban environment such as Manhattan, with its severe attenuation characteristics, will tax the economic structure of PCS services as the number of cells required to provide coverage increases. Omnipoint's very small, low cost, Base Stations may be installed on the sides of buildings to provide high quality service into these canyons while maintaining the cost parameters required for successful economic implementation of PCS.

For Manhattan, 10 Sites were initially selected, and chosen based on a general model of propagation patterns and the fact that cells look more like lines and crosses than circles in urban canyons. For these initial 10 sites, environments included a combination of single and multi-lane streets and avenues varying in width from 60 to 200 feet, flanked by 30 to 60 floor high rises creating deep urban ravines, as well as 5-10 story shallow RF "crevasses". Base Stations were installed between the 5th and 11th floors, and signal strength measurements were taken and plotted in the vicinity of each location. Additionally, coverage plots of the Omnipoint system at each site were generated, and qualitative Figure of Merit scores were given. Further tests were performed where varying combinations of Base Stations were used on a system basis, with repeated drive and walking tests on established routes, and handoff, audio quality, and 2GHz propagation characteristics and their effect on Omnipoint's spread spectrum system were studied.

Base Station Locations - Manhattan

Three configurations, each consisting of 10 cell sites, were utilized for different drive and walk routes, and were selected for their environmental diversity and location relative to all other cell sites for large scale coverage and analysis of an N=3 re-use pattern. The locations of the Base Stations for Configurations 1, 2 and 3 are summarized in Tables 4- 1, 4-2 and 4-3 and Figures 1-1, 1-2, and 1-3, respectively. All Base Stations function with the following parameters:

Transmit Power	0.1 W (20 dBm)
Radiation Center :	50 - 100' AGL, side mounted
Antenna :	3 dBd omnidirectional
Effective Radiated Power (ERP) :	0.2 W (23 dBm)

Table 4-1
Base Station Configuration No. 1

	Manhattan Sites	Center Frequency (MHz)
1.	47th St and Lexington Ave.	1970
2.	52nd St. and Madison Ave.	1910
3.	55th St. and 5th Ave.	1925
4.	55th St and Broadway	1970
5.	52nd St. and Eighth Ave.	1925
6.	56th St. and Seventh Ave.	1910
7.	56th St. and Park Ave.	1970
8.	51st St. and Park Ave.	1925
9.	42nd St. and Madison Ave.	1925
10.	53rd St. and Fifth Ave.	1970

Table 4-2:
Base Station Configuration No. 2

	Manhattan Sites	Center Frequency (MHz)
1.	47th St and Lexington Ave.	1910
2.	52nd St. and Madison Ave.	1925
3.	55th St. and 5th Ave.	1910
4.	55th St and Broadway	1970
5.	52nd St. and Eighth Ave.	1910
6.	56th St. and Seventh Ave.	1925
7.	56th St. and Park Ave.	1970
9.	42nd St. and Madison Ave.	1970
10.	53rd St. and Fifth Ave.	1970
11	51st St. and Lexington Ave.	1925

Table 4-3:
Base Station Configuration No. 3

	Manhattan Sites	Center Frequency (MHz)
1.	47th St and Lexington Ave.	1970
2.	52nd St. and Madison Ave.	1910
3.	55th St. and 5th Ave.	1925
4.	55th St and Broadway	1970
5.	52nd St. and Eighth Ave.	1925
6.	56th St. and Seventh Ave.	1910
7.	56th St. and Park Ave.	1970
8.	51st St. and Park Ave.	1925
10.	53rd St. and Fifth Ave.	1970
12.	44th St. and Lexington Ave.	1925

It is seen from Figures 1-1, 1-2, and 1-3 that the three cell frequency re-use pattern discussed above in section 3 is employed several times through the three configurations.

4.3 Manhattan Test Descriptions and Results

Signal Strength Tests

As part of Omnipoint's initial cell site planning efforts, extensive signal strength measurements at each site were performed in conjunction with LCC. The attached RSS and Fade Margin Plots detail the results for each cell site, as well as the composite coverage of all cell sites.

Individual Site Tests

Base Stations installed at each site were tested individually for signal quality, and antenna placements determined as a function of the particular mounting choices available at each location. The testing conducted included subjective signal quality as a function of both LOS and NLOS distance from the Base site where Figure of Merit (FOM) scores were awarded based on a scale of four levels, and coverage plots were generated from a single cell site with handoff disabled. These FOM scores were then used to graphically display the relationship between each test point and the Base site:

Table 4-4
Qualitative Figure of Merit Scores

Level	Plot Color	Rating
1	Red	Excellent: Clear audio/voice, no noise
2	Blue	Good: Minor muting or even a single audible "pop"
3	Green	Marginal: More muting, still intelligible voice
4	Violet	Poor: unacceptable voice, but link intact

Typical of the coverage plots for Base sites are Figures 1-9 and 1-8. Site 1, located at 47th St. and Lexington Ave., is a typical East/West corridor installation, with Excellent to Good coverage from 1st Ave to Eighth, a distance of almost 6000 feet. With antennas installed on an

East/West orientation on 47th Street, Excellent to Good coverage is also provided North/South in NLOS from 54th to almost 42nd Streets, a distance of approximately 2900 feet.

Similarly, Figure 1-8 shows performance of a typical North/South corridor installation. At this site, Excellent to Good coverage is available for almost 7500' North and South on Madison Avenue, from 38th past 66th Streets.

Table 4-5 summarizes the maximum linear range achieved for each installation on it's primary North/South or East/West corridor. Wider North/South avenues typically allowed for greater distances than narrower East/West streets, but adequate coverage was achieved on all of these primary corridors with a Base Station ERP of approximately 200mW. As discussed, rapid signal fades on the order of 20-30dB typically occur when turning the corner from primary coverage corridors.

Figure 1-18 shows the composite coverage plot for configuration 1 for the total area served effectively.

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TABLE 4-5

System Coverage, Configuration No. 1

NUMBER	SITE	STREET	DIRECTION	FOM <= 3 DISTANCE (ft)
1.	47th & Lexington	47th	E	1,708
			W	4,204
2.	52nd & Madison	Madison	N	3,600
			S	3,873
3.	55th & 5th	55th	E	1,971
			W	3,153
4.	55th & Broadway	55th	E	2,890
			W	2,760
5.	52nd & 8th	8th	N	2,233*
			S	3,022
6.	56th & 7th	56th	E	3,547
			W	3,679
7.	56th & Park	56th	E	2,102
			W	4,073
8.	50th & Park	Park	N	3,600*
9.	42nd & Madison	Madison	N	2,836
			S	2,727
10.	6th & 55th	6th	N	1,200**
			S	3,600
11.	50th & Lexington	Lexington	N	2,509
			S	2,073
			Average****	3,049

* Stopped at Central Park

** Antennas configured for coverage N of Park only

***Excludes No. 8, South, and No. 5, North

Manhattan System Tests

Once Base hardware for each configuration was installed, mobile units were driven and walked throughout the covered areas. All hardware employed in this test fully supports two-way calling. Operational characteristics (multipath mitigation, range, signal quality, hand-off, etc.) at varying speeds were measured. Two drive paths ("Long" and "Short") were chosen to determine signal quality and coverage over the many environments present in the area covered by the Base Stations of the three configurations, restricted by street directions, traffic patterns and density, etc.

"LONG" route - The long path (approximately 2.8 miles) offers a variety of environments to study signal quality and handoff capabilities. This route starts at 47th St and First Ave, and proceeds west to Madison Ave (North), 55th St. (West), and Eighth Ave (North), to Columbus Circle. The path follows Columbus Circle to Broadway (South), and to 56th St (East), and then proceeds to Park Ave (South), and ends by turning left at 50th St and stopping at the southeast corner of 50th and Park. This path travels through a wide (two lanes, two way plus center island) & deep (30 to 70 floor buildings flanking the avenue) "canyon" (Park Avenue), medium (3 lanes, one way) & deep canyons (Madison, Eighth & Broadway), narrow (one to two lanes, on way) & shallow (5 to 30 floor buildings) "crevasses" (55th and 56th), and a moderately open section around Columbus Circle, and presents a variety of traffic situations.

Different handoff situations are present, from quick hand-off events as the vehicle or pedestrian turns a corner and experiences a 20-30dB near instantaneous building shadow fade, to a same-street hand-off where excessive deep fading or vehicular shadowing could cause hand-off from the source to the destination Base Station to access anywhere over a 100 to 300 foot handoff "zone".

"SHORT" route - The short path (approximately 0.9 miles) experiences a less diverse set of environments, but does allow for faster collection of data for analyses hand-off events and a close N=3 reuse pattern. The Short path begins at the intersection of 47th St and First Ave, proceeding West to Madison (North) to 56th (East) to Park Ave (South), and back to 47th (West). Transportation of the mobile through this route allows for quick hand-offs at each right turn due to building shadowing, allowing for a detailed study of rapidly changing RF environments.

Mobile System Link Quality Test Results

Over a period of several days, 31 runs were made on the long route, and 11 runs on the short route. During the tests, the traffic conditions affected the test environment , which changed significantly from test to test, providing each run its own unique parameters. Tests were conducted at all times of the day and night, with run times varying from less than 6 minutes at 3:00am on the short route to as long as 1½ hour runs during rush hour. As tedious as some of the longer runs may have been, the contrast in run times allowed for testing at very different speeds; from stopped for several long minutes during gridlocked rush hour, to walking when Madison Avenue was closed for a day during the test period for a street fair, to relatively high speed runs in the early morning hours. While a walk through Manhattan at 3:00am may be an educational experience itself, all night tests, regardless of traffic conditions, were performed from a vehicle for continuity and safety reasons. As a result of this extensive testing, Omnipoint field engineers came away with abundant technical test results.

For each test, a standard Omnipoint 2GHz PCS Handset was utilized as the mobile unit, and was powered through an adapter by the battery of the vehicle or employed a standard pocket phone 700mAh battery. As the mobile progressed through each route, Figure of Merit scores were given to the link quality, and handoff events marked on a map. These individual runs were then compiled to generate a composite picture of system performance through FOM scores and to establish handoff zones throughout the route.

Long route composite summary - From the 31 runs on the long route of approximately 2.8 miles, an accurate picture of coverage provided by the Base installations was derived over a wide variety of operating conditions.

Beginning at the intersection of First Avenue and 47th Street, the test vehicle would proceed westbound on 47th to Madison Avenue. During this stretch of the route, traffic is typically dense, and this 5 block section can take 30 seconds to 30 minutes, depending on traffic conditions. Regardless of the speed with which this section was negotiated, coverage for the entire 5 blocks was consistently excellent, or rated as a "1" on the FOM scale. Upon turning right at Madison, heading north, the signal would encounter very rapid shadowing, at which time the first handoff in the route would occur. This handoff event occurred without exception by mid-block between 47th and 48th Streets, usually without audible defects due to the large structural shadowing right at the northeast corner of the intersection creating a 30 - 40dB disparity between the signals from the two base stations placed at approximately equivalent distance from the handoff zone, but on orthogonal streets. In the center of the intersection of 47th and Madison, the handset sees similar signal quality from both Base Stations, but maintains its link to the original Base as there exists no reason for a handoff. When the Handset passes around the corner from 47th to Madison the 47th signal experiences a rapid drop, and handoff to the higher quality (and in this case, much higher level) signal occurs. This handoff typically happens in 12 - 18 milliseconds, and may or may not be accompanied by a barely audible instantaneous muting.

The next section of the route is on Madison Avenue between 47th and 55th Streets, and is a wider street than 47th, with 3 lanes of traffic in one direction (north). Proceeding north on Madison, signal quality remains excellent for most of the section, with the exception of a small area near 53rd Street where signal quality on the order of FOM2 exists, meaning slight packet muting. On 10% of the runs, this area also experienced short sub 1 second periods of FOM3 levels, but no severe muting was noted. The left turn onto 55th Street caused another handoff, where all handoff events occurred within a half block of Madison, and again were very rapid (on the order of 18 - 20 milliseconds). The handoff is the same experienced at 47th and Madison, with rapid shadowing and significant signal quality disparity between Base Station signals dominating the decision.

Section 3 of the long route is 55th Street (narrow) between Madison and Eighth Avenues. Signal quality remained excellent from handoff at Madison to just before 6th Ave, where a localized region of mostly FOM1 but some 2 scores were present. This area contains a varied mixture of high rises and smaller buildings where different multipath characteristics are present than those of the first two sections. Signal quality returned to excellent shortly after passing though the Sixth Ave intersection, then entered another small area of mostly FOM1 and 2 scores, with an occasional FOM3 at Seventh Ave. At this point, environmental factors began to play a larger role as the handset transferred to another Base. This handoff region is larger than the first two and could occur anywhere over approximately one city block, a half block east and west of Seventh. As the handset entered this zone, differences in signal quality, due mostly to fast